THERMAL FRACTURING, UNDERWATER AMBIENT NOISE MEASUREMENTS AND MODELING

Dr. Peter J. Stein and Dr. Subramaniam D. Rajan
Scientific Solutions, Inc.
18 Clinton Drive
Hollis, NH 03049-6576
pstein@mv.mv.com and rajan@gte.net
Voice: (603) 880-3784 Fax: (603) 598-1803

Dr. James K. Lewis
Ocean Physics Research & Development
207 S. Seashore Ave.
Long Beach, MS 39560
ocnphys@aol.com
Voice: (228) 865-0059 Fax: (228) 864-3268

Award No. N00014-97-C-0294

LONG TERM GOALS

The long term goal is to understand the relationship between the environmental conditions, ice properties, ice geometry, and the thermal fracturing of ice and the resulting underwater ambient noise. By doing this we hope to determine the effect of thermal fracturing on the strength of sea ice and its possible influence on climate change.

OBJECTIVES

Thermal fracturing occurs when rapid temperature changes, mainly cooling of the upper surface, stress the pack ice. Recent work conducted during the Sea Ice Mechanics Initiative (SIMI) has shown the importance of thermal fracturing. Figure 1 (top) shows data acquired during the CEAREX experiment. Plotted are the minimum and maximum underwater ambient noise levels in third octave bands. There are two separate driving mechanisms forcing the ambient noise. The low frequencies, below 100 Hz, are dominated by motion induced mechanisms. The higher frequencies are dominated by thermal fracturing activity. Thus, thermal fracturing is one of the primary source of the ambient noise which interferes with sonar systems. Strong thermal fracturing occurs one or more times per week. Work conducted during SIMI also indicates that thermal fracturing is one of the primary means of weakening the pack ice at the 100 m scale. A weakening of the pack ice implies an increase in the formation of open areas of water (leads), and hence greater heat flux between the ocean and the atmosphere. Thus, changes in the thermal fracturing rate may influence climate change in the Arctic.

Our objective is to formulate a complete model for thermal fracturing and the resulting ambient noise. Figure 1 (bottom) shows our most recent attempt at doing this. Inputs to the model are also given in Figure 1. We see good agreement in the example shown, however there are some regions of disagreement. Other data/model comparisons do not look as good. To

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **30 SEP 1997**	2. REPORT TYPE	3. DATES COVERED **00-00-1997 to 00-00-1997**

4. TITLE AND SUBTITLE **Thermal Fracturing, Underwater Ambient Noise Measurements and Modeling**	5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Scientific Solutions, Inc,18 Clinton Drive,Holis,NH,03049**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S) 11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**4**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

improve the models we need more long term ambient noise data sets where all the relevant meteorological data is also collected. This includes heat flux and snow cover data. A very complete long term meteorological data set will be collected during the NSF/ONR sponsored Surface Heat Budget of the Arctic (SHEBA) experiment. Our most recent objective has been to design, build, and deploy three autonomous measurement systems during the SHEBA experiment to collect the complimentary ambient noise data.

APPROACH

The autonomous Arctic ambient noise measurement system is shown in Figure 2 prior to shipping. A watertight box houses the batteries, data acquisitions computer, signal conditioning electronics, and satellite telemetry gear. In the foreground of Figure 2 (small black object) is the hydrophone and 100 m of anti-strum cable. Mounted on a the pole is a GPS antenna, an ARGOS antenna, and four diode isolated solar panels. Four solar panels are used so one will always be facing the sun. The batteries are sized to make it through 6 months of darkness. Thus, the system should run indefinitely unless destroyed by the elements. The computer takes ambient noise data once per hour averaged over 20 seconds. The computer then calculates third octave bands and statistics of the noise sample. The ice stress is also measured once per hour. The third octave band levels, statistics, ice stress data, location, and time are telemetered back via ARGOS. In the SHEBA experiment, the main camp will be supported by a permanently stationed icebreaker frozen into the ice. To reduce contamination from ship noise, our systems will be deployed 50 km from the camp.

ACCOMPLISHMENTS

Under this contract, we have designed and built three autonomous ambient noise measurement systems. The systems have been shipped to the Arctic and are being deployed as of this writing. If these systems work properly, this should give the most complete data set yet available for studying thermally induced stresses, fracturing, and underwater ambient noise.

IMPACT FOR SCIENCE/ SYSTEMS APPLICATIONS

Over the past several years we have made great advances in understanding the thermal stressing of the ice, the resulting fracturing of the ice, and ambient noise. We will use the data acquired during SHEBA to further understand the fracturing mechanisms and to improve our models.

TRANSITIONS

Eventually the models developed will be transitioned into operational models used by the Navy Fleet for predicting ambient noise and system performance. The models will also be incorporated in ice/ocean/atmosphere models for use in climate predictions studies. The autonomous ambient noise measurement system might also be transition into a multi-year monitoring of ambient noise. By monitoring the ambient noise we might be able to determine if there are any changes in the rate of thermal fracturing. This may yield clues as to the direction of climate change in the Arctic and the importance of thermal fracturing.

RELATED PROJECTS

Scientific Solutions is also involved in developing a radiometer system for making remote unmanned radiometric measurements under harsh conditions. Eight advanced prototype units are

being deployed during the SHEBA experiment to make remote radiation measurements away from the camp and the ship contamination.

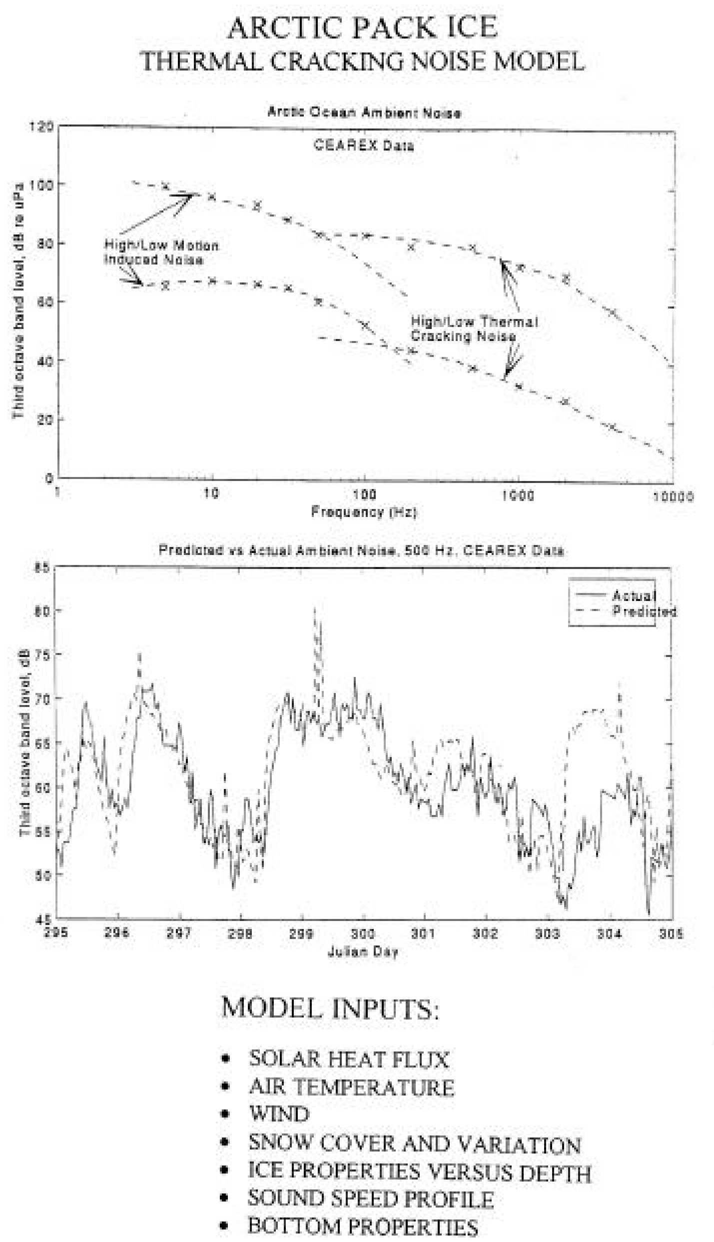

Figure 1. Modelled data comparison for thermal cracking noise.

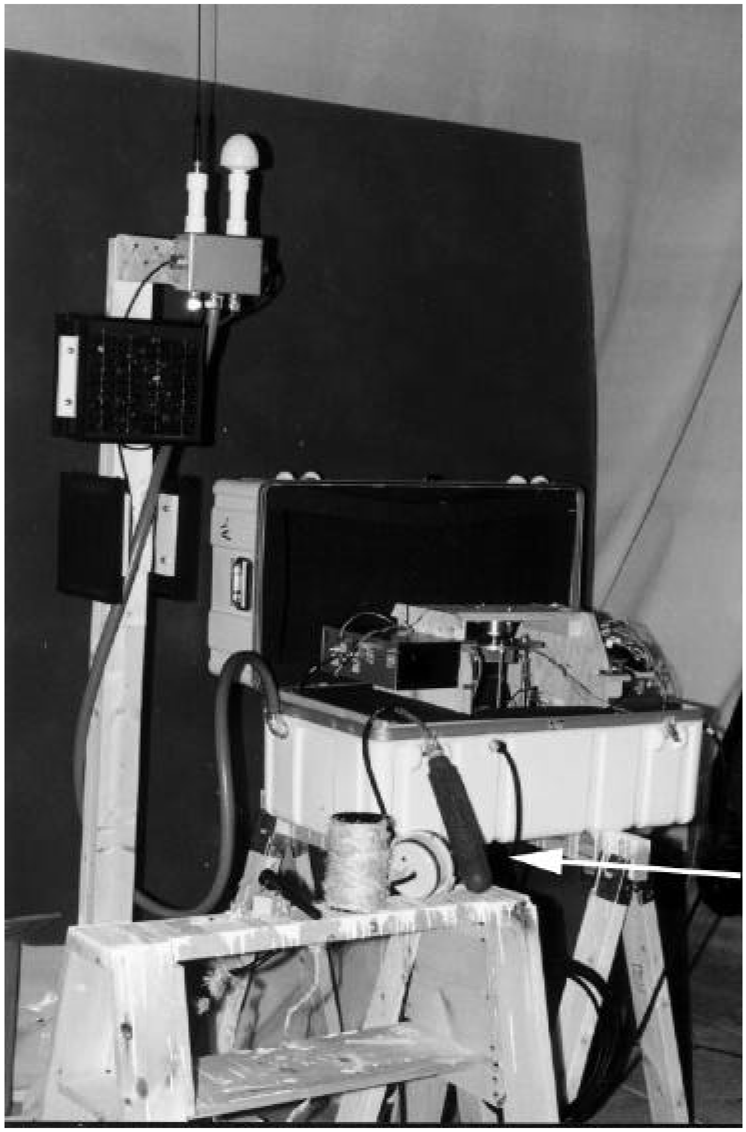

Figure 2. Autonomous ice stress/ambient noise measurement system.